CLAIMS

What is claimed is:

1. A method of operating a dual-duplex communications system having A and B channel transmitters in a first dual transceiver operatively coupled through A and B loops to corresponding A and B channel receivers in a second dual transceiver, the method comprising the steps of:

a. operating the system in a training mode to initialize timing synchronization between the first and second dual transceivers, wherein the training mode includes the steps of

directing identical channel training data to the respective A and B channel transmitters in the first transceiver, wherein the training data produces a known sequence of symbols,

concurrently transmitting the training data across the A and B loops to the A and B channel receivers in the second transceiver,

automatically adjusting receiver parameters in at least one of the A and B channel receivers in the second transceiver so that the training data is correctly received and time aligned in each of the A and B channel receivers; and

b. switching the system to operate in a data mode.

2. The method of claim 1 wherein the training mode further includes the initial steps of:

a. transmitting the training data from the A channel transmitter to the A channel receiver; and

b. adjusting the receiver parameters in the A channel receiver until at least a portion of the sequence of symbols in the training data is correctly recognized in the A channel receiver.

3. The method of claim 2 wherein each of the A and B channel receivers include an equalizer and the receiver parameters that are adjusted in the training mode include equalizer coefficients.

4. In a data communications system having central office A and B channel transmitters and receivers coupled by A and B loops to corresponding remote A and B channel transmitters and receivers, a method of time aligning in the central office and remote A and B channel receivers data signals that are time aligned in the corresponding remote and central office A and B transmitters, the method comprising automatically adjusting electrical parameters in at least one of the A and B channel receivers during a training mode such that any transmission delay introduced by one of the A or B loops is effectively created in the other A or B channel so that when the system is operated in a data mode there is no differential signal transmission delay operable between the A and B channels.

5. The method of claim 4 further comprising sending, during the training mode, a known sequence of A channel training data across loop A while

concurrently sending B channel training data across loop B, and wherein the B channel training data is mathematically derived from the A channel training data.

6. The method of claim 5 wherein the step of adjusting electrical parameters in a least one of the A and B channel receivers during the training mode includes adjusting equalizer coefficients in the receiver using table directed training.

7. A method of time synchronizing the reception of first symbols from a first transmitter functionally coupled by a first loop to a first receiver and second symbols from a second transmitter functionally coupled by a second loop to a second receiver where each transmitter is driven by a known sequence of symbols, the method comprising the steps of:

training a first equalizer in the first receiver using decision directed training;

detecting the known sequence of symbols at the output of a first descrambler coupled to the first receiver;

copying the detected sequence of symbols as contents of the first descrambler to a training scrambler such that the training scrambler is driven by the known sequence of symbols; and

training the first equalizer and the second equalizer with the output of the training scrambler using table directed training.

8. The method of claim 7 where the known sequence of symbols is produced by a sequence of "1's".

9. The method of claim 7 where the symbols are generated using uncoded 4-QAM.

10. The method of claim 7 further comprising switching to a data mode upon completion of training by the training scrambler.

11. The method of claim 10 wherein a data rate on the first channel is substantially equal to a data rate on the second channel.

12. The method of claim 10 further comprising the steps of

receiving an input data stream from a central site; and

separating the input data stream into a first input stream for the first transmitter and a second input data for the second transmitter

modulating the first input stream in the first transmitter forming a first modulated signal;

modulating the second input stream in the second transmitter forming a second modulated signal;

transmitting the first and second modulated signals over the respective first and second loops.

13. The method of claim 12 further comprising the steps of;

demodulating the first modulated signal in the first receiver;

demodulating the second modulated signal in the second receiver; and

combining the first and demodulated signals forming an output data stream.

14. A method of transferring a data stream from a central location to a remote location using a first wire pair and a second wire pair, where the wire pairs may have different transmission delays, the method comprising:

simultaneously transmitting, during an initial training mode, identical training data across the first and second wire pairs, the training data comprising a sequence of scrambled ones;

training a first linear equalizer in a first receiver and a second linear equalizer in a second receiver using the sequence of scrambled ones;

switching to a data mode when the linear equalizers are trained;

separating an input data stream into first and second data streams;

modulating the first data stream in a first transmitter and the second data stream in a second transmitter;

transmitting the output of the first transmitter across the first pair of wires and the output of the second transmitter across the second pair of wires;

receiving the output of the first transmitter at a first receiver and the output of the second transmitter at a second receiver;

generating a first receiver data stream and a second data receiver stream; and

combining the first receiver data stream and the second data receiver stream to form an output data stream.

15. A device for communicating data across A and B loops characterized by having a differential transmission delay between first and second ends of the loops, the device comprising:

a. A and B channel transmitters functionally coupled to a the first ends of the corresponding A and B loops;

b. A and B channel receivers functionally coupled to the second ends of the corresponding A and B loops; and

c. training means to automatically adjust electrical parameters in at least one of the A and B channel receives when the device is operated in a training mode so that when the device is operated in a data mode, the differential transmission delay between the A and B loops effectively canceled.

16. The device of claim 15 further comprising means to connect the A and B channel transmitters to a source of training data whereby, during the training mode, each A and B channel transmitter concurrently transmits an identical known sequence of scrambled symbols to the A and B channel receivers.

17. The device of claim 15 wherein, during the training mode, the A channel transmitter transmits A channel training data comprising a known

sequence of scrambled symbols and the B channel transmitter concurrently transmits B channel training data comprising a sequence of scrambled symbols that is derived from the A channel training data.

18. The device of claim 15 wherein

the A and B channel receivers further comprise respective A and B channel equalizers,

the electrical parameters that are adjusted during the training mode include coefficients in at least one of the A and B channel equalizers,

the training means includes a training scrambler functionally coupled to the A and B channel receivers during the training mode,

and the training means is operable to provide table directed training of the A and B channel equalizers during the training mode.

19. A device for transferring a user data stream from a central location to a remote location using a first wire pair and a second wire pair, where the first and second wire pairs may have different transmission delays, the device comprising:

a first transmitter and a second transmitter operable, in a training mode, to send a scrambled sequence of symbols across the first and second wire pairs;

a first receiver and a second receiver operatively coupled respectively to the first wire pair and to the second wire pair, the first and second

receivers comprising respective first and second linear equalizers, the linear equalizers having equalizer coefficients adjustable during the training mode;

means for switching the device to a data mode upon termination of the training mode;

a data separator for separating the user data stream into a first data stream sent to the first transmitter and into a second data stream sent to the second transmitter; and

a data combiner for combining a first receiver data stream and a second receiver data stream forming an output data stream.

20. A method of operating a data transmission system in which a single user data stream is separated into multiple data streams for transmission by corresponding multiple data transmitters over multiple wire pairs for reconstruction into the single user data stream in corresponding multiple data receivers comprising the steps of:

operating the system in a training mode by concurrently sending a known sequence of training data from each of the transmitters across the wire pairs to each of the receivers,

whereby the sequence of training data sent across one of the wire pairs is either identical to or mathematically derived from the sequence of training data sent across the other wire pairs,

using the training data to cause timing adjustments in at least some of the receivers so that any differential transmission delay associated with the different wire pairs is effectively eliminated; and

operating the system in a data mode using the timing adjustments set during the training mode so that user data that is time aligned in the multiple data streams in the transmitters is also time aligned in the receivers.

21. The method of claim 20 wherein the step of causing timing adjustments in the receivers includes adjusting receiver equalizer coefficients.

22. A method of training equalizers in A and B channel receivers in a data communications system that includes a data splitter coupled to A and B channel transmitters that are operatively linked to the A and B channel receivers across first and second two wire pairs forming A and B loops, and where the A and B channel receivers include respective A and B channel descramblers functionally connected between A and B channel decision modules and a data combiner, the method comprising the steps of:

a. sending a known sequence of training symbols from the A channel transmitter to the A channel receiver;

b. decision training the A channel equalizer by adjusting A channel equalizer coefficients while testing at the A channel descrambler for correct decisions made by the A channel decision module corresponding to the known sequence of training symbols;

c. copying training information from the A channel descrambler to a training scrambler having an output functionally linked to the A and B channel equalizers;

d. concurrently sending the known sequence of training symbols from the A and B channel transmitters to the A and B channel receivers;

e. training the A and B channel equalizers together by using outputs from the A and B channel scramblers as decisions and adjusting equalizer coefficients in at least one of the A and B channel equalizers until the A and B channel decision modules are making correct decisions in accordance with the known sequence of training symbols, and the data combiner is providing an output in which data that is time aligned at the data splitter is also time aligned at the data combiner even in the presence of a differential transmission delay between the A and B loops.